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Biology of a *Pegomya* Fly (Diptera: Anthomyiidae) Attacking the Parasitic Plant *Boschniakia* (Orobanchaceae)

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Abstract.—The anthomyiid fly *Pegomya hyperparasitica* Deyrup deposits its eggs in the flowers of *Boschniakia hookeri* Walpers, a parasitic plant growing on roots of various Ericaceae in western Washington State. Larvae feed in the ovaries, then bore into the fleshy stem of the inflorescence. Pupae are in soil near the base of the plant. Adults emerge from late March through April. The fly greatly decreases seed production, without injuring non-reproductive parts of the plant.

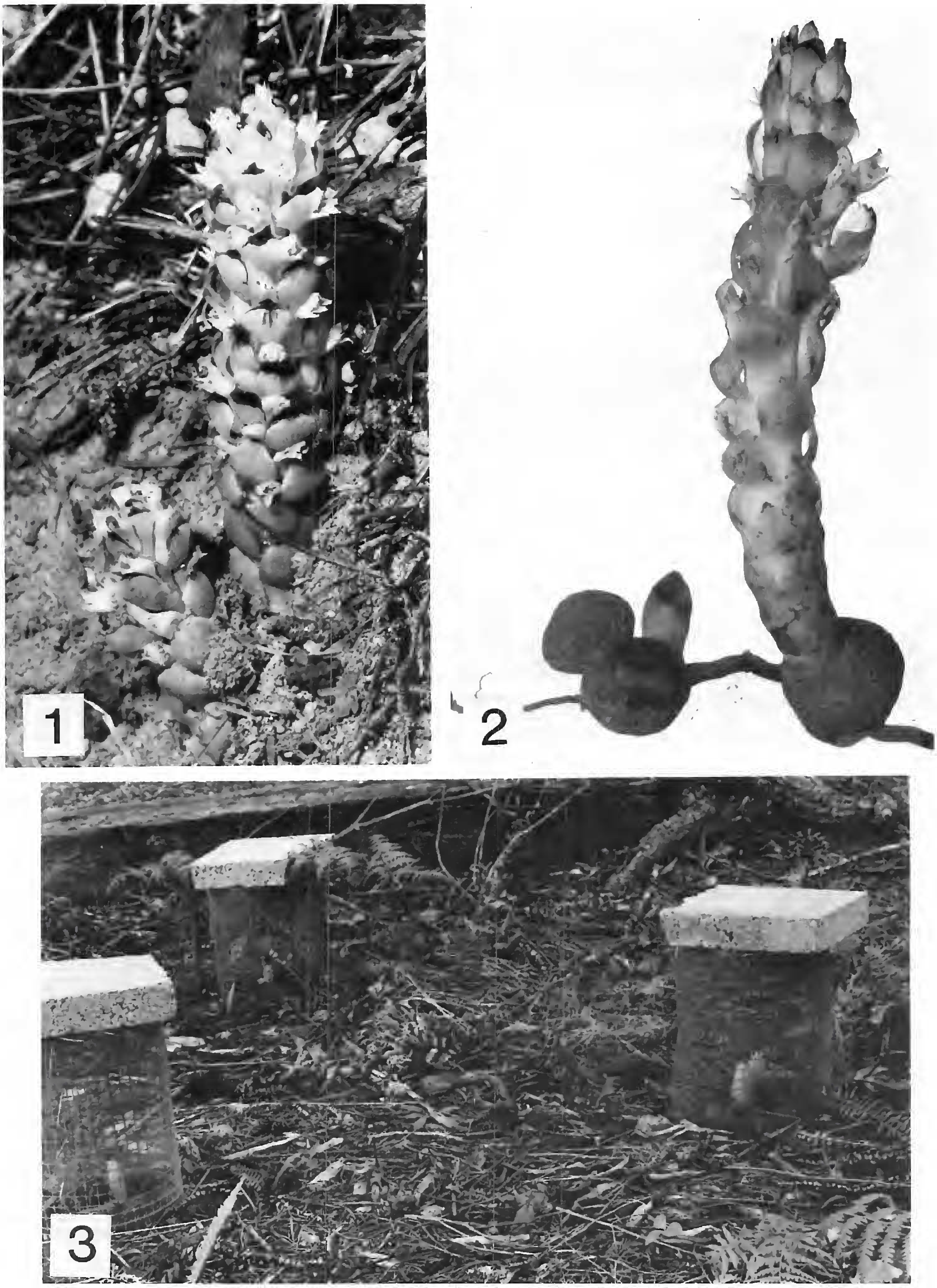
In the preceding paper in this issue the anthomyiid fly *Pegomya hyperparasitica* Deyrup was described from specimens reared from the plant *Boschniakia hookeri* Walpers. *B. hookeri* is a perennial parasitic plant that attacks roots of a number of species of Ericaceae along the coastal regions of Washington, Oregon, and British Columbia. The plant occurs as a tuber-like growth that sends up one or more fleshy flowering stalks during spring (Figs. 1, 2).

METHODS

P. hyperparasitica was studied from the spring of 1977 through the summer of 1979 at Bear Lake (Section 36 of T122N, R1W) in the Puget Sound Lowlands, on the Kitsap Peninsula in western Washington State. The topsoil is an easily-permeated gravelly sandy loam. Observations were concentrated in a property lot of about 270 m^2, belonging to S. and I. Olsen. An unusually dense population of *B. hookeri,* several hundred plants, occurs on this site. The climate of the site is characterized by mild winters (avg. temp. 4°C) with heavy precipitation (around 1100 mm), and summers that are cool (avg. temp. 18°C) and dry (around 250 mm precipitation).

Pupae were collected in the field by digging below damaged inflorescences during June–August. Pupae were placed in plastic petri dishes with a thin overlay of soil or on moistened filter paper, and kept over the winter in an unheated shed. Cylindrical enclosures covering an area of ground about 225 cm^2 were made from wire screening covered with mosquito netting (Fig. 3). These cages were set up in early spring 1979 over the site of plants that had been damaged in 1978. Since the flies emerge before the plants, the same enclosures could be used to exclude flies in 1979. Smaller enclosures, about 80 cm^2 were also used to exclude flies,

† Deceased.



Figures 1–3. 1. Flowering stalk of *B. hookeri*. 2. Complete plant of *B. hookeri*. 3. Cages used to both trap and exclude flies.

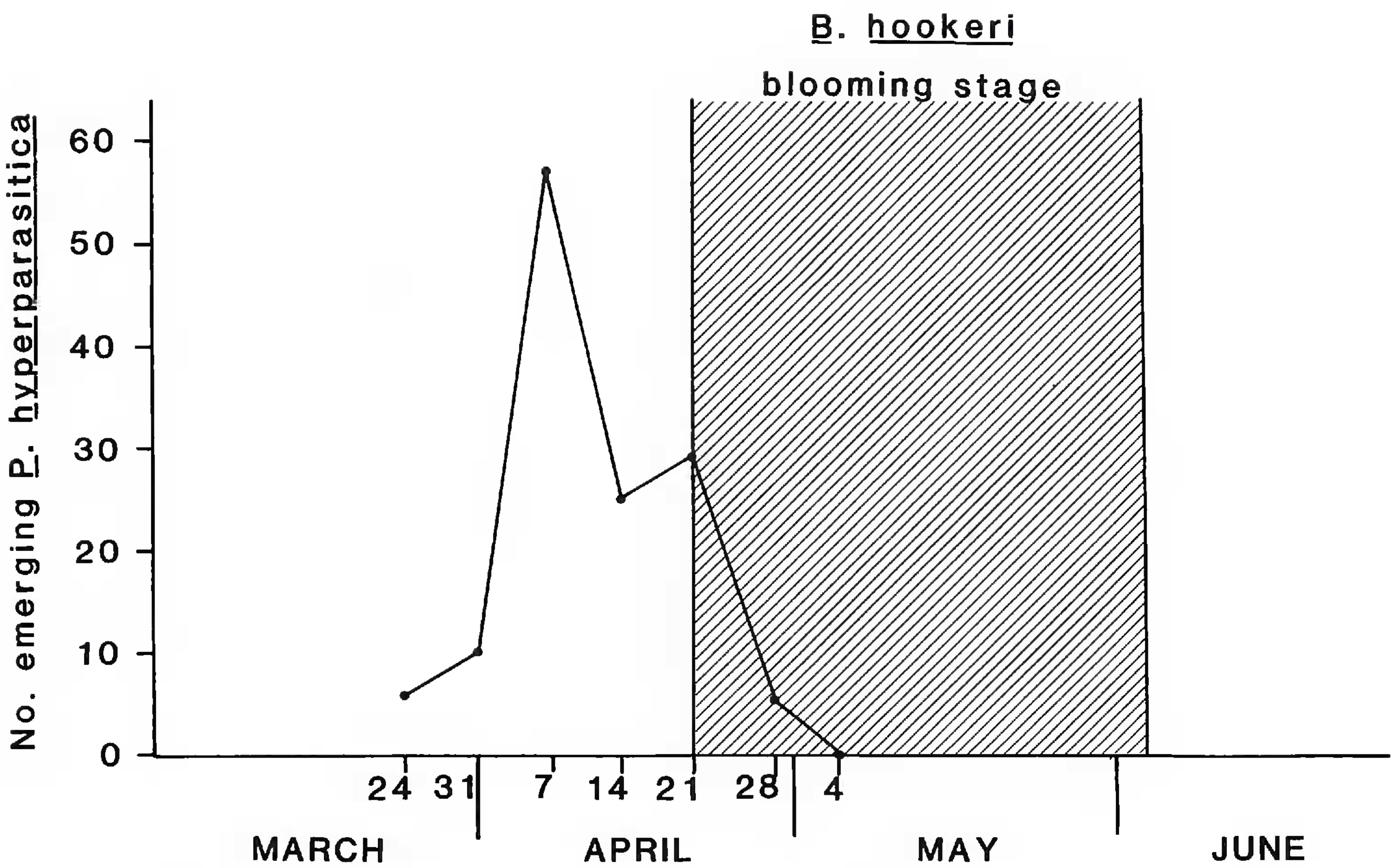


Figure 4. Emergence of *P. hyperparasitica* ($n = 132$) and blooming period of *B. hookeri* ($n = 585$).

but were ineffective in trapping. Six large and 7 small traps were set out on 19 March 1979 and examined for flies weekly through June 1979.

Details of the effects of larvae on the flowers and the stem were photographed with a Nikon-F camera using Nikon PB-4 bellows and Zeiss Luminar lenses (100, 63, 40 mm). Illumination was provided by a Bowens Multitec Tecturelite.

Life History and Behavior of Fly

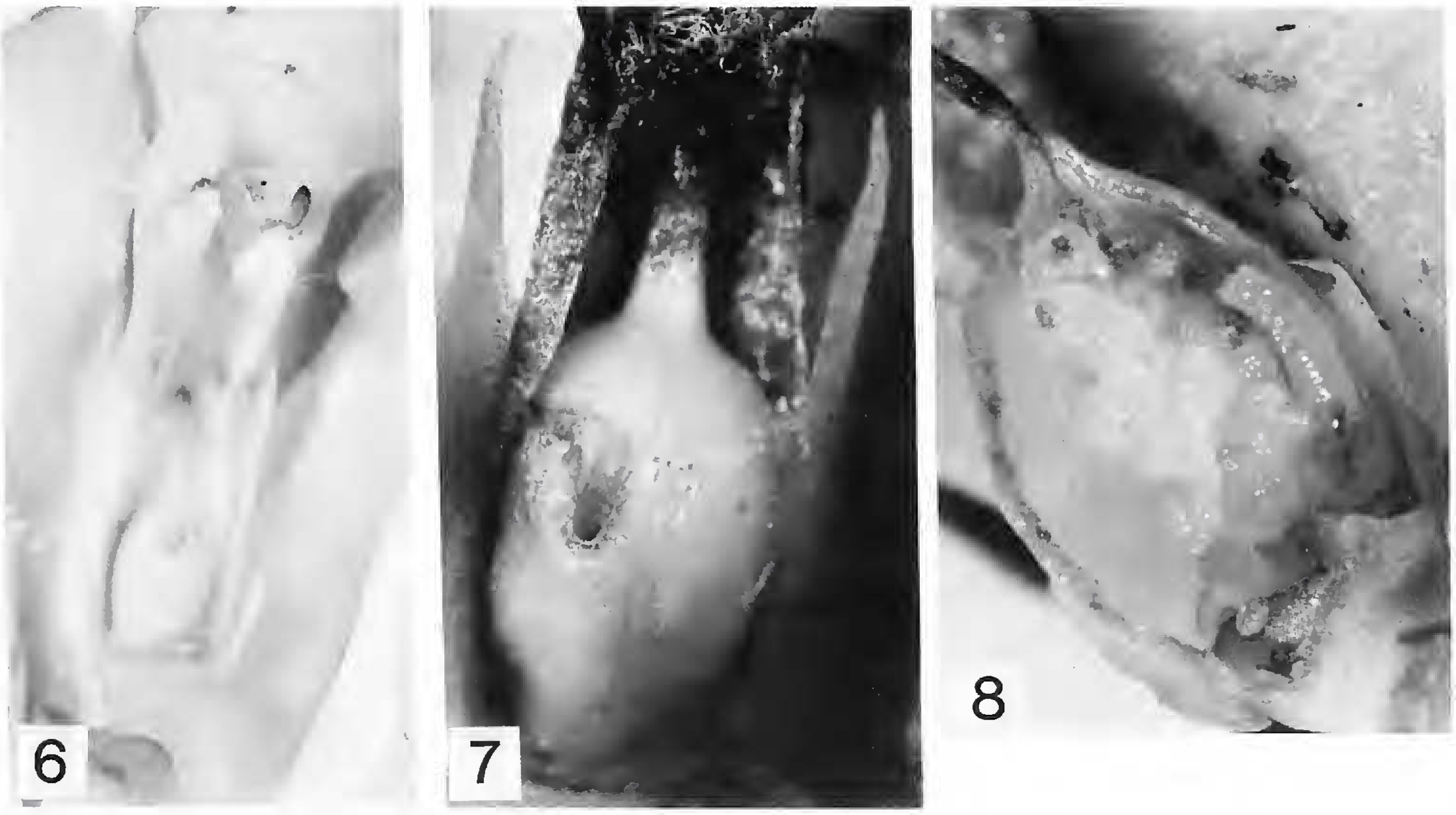
In the field adult emergence begins in late March and continues into early June, based on records of 132 flies captured in 1979. Seventeen flies emerged from pupae kept in petri dishes over the winter; these began to emerge 4 days earlier than flies collected in the field, and had completed emergence 9 days earlier. The first flies emerging in the field appeared 23 days before the first flowers opened, and emergence was complete long before the blooming season reached its peak (Fig. 4). This implies that the flies require considerable maturation time, or that there is a strong advantage associated with ovipositing on the earliest flowers. Even in the laboratory, where flies were maintained in closed containers and not fed, the flies lived for several weeks, easily spanning the time between eclosion and availability of *Boschniakia* flowers. Except for the flies emerging in enclosures, no flies were seen in the field until ovipositing females appeared on the flowers in May.

Oviposition was observed repeatedly and the typical oviposition stance photographed (Fig. 5). The female backs into the flower until about half the abdomen is concealed in the flower. A single egg is laid on an anther (Fig. 6). The ovipositor is rather simple compared with that of *Pegomya* species that insert eggs into the tissues of plants, but is equipped with long hairs that might be used to locate an

Figure 5. *P. hyperparasitica* ovipositing in flower of *B. hookeri.*

anther. Upon hatching, the larva bores into the ovary (Fig. 7), where it feeds on the developing seeds (Fig. 8). When the young seeds have been eaten, the larva moves into the soft stem of the inflorescence, working downward while feeding (Fig. 9). The larvae leave the stem near ground level and burrow down to about the level of the tuber-like body of the plant. Pupation occurs in this zone.

The feeding habits encompassed in the genus *Pegomya* are diverse, including leaf-mining, boring in canes of *Rubus,* stems of *Equisetum,* and stems of mushrooms (Griffiths, 1982, 1983, 1984a, 1984b). Of the 94 species listed by Griffiths, hosts are known for 49; 27 species are leaf-miners, and 18 are mushroom feeders. The morphological characteristics of most of the species with unknown hosts strongly suggest that these are also leaf-miners or mushroom feeders. *P. hyperparasitica* is the only species known to feed on seeds and flower stalks and is thus ecologically as well as morphologically isolated from other *Pegomya.* The structure of the male pregonite and postgonite of *P. hyperparasitica,* especially the enlarged, flattened seta of the postgonite (likely to be a derived character state), suggest a closer relationship with some of the fungus-feeding species groups. Since *B. hookeri* is somewhat fungoid in appearance, lacks chlorophyll (possibly of nutritional significance), and can be attacked without any specialized structures on the ovipositor, there is some ecological justification for considering *P. hyperparasitica* a radical offshoot of a mycetophagous lineage.



Figures 6–8. 6. Egg of *P. hyperparasitica* on anther of *B. hookeri.* 7. Entrance hole of fly larva. 8. Fly larva among seeds.

We strongly suspect that *P. hyperparasitica* is a monophagous species. The specific oviposition site and the two sequential larval feeding sites suggest a specialized species. We have reared a few of these flies from pupae collected around *B. strobilacea* Gray in Oregon, but since this plant is often considered a southern variant of *B. hookeri* (Hitchcock et al., 1959), these records do not affect the monophagous status of the fly. We examined local specimens of two other parasitic plants, *Allotropa virgata* Torrey and Gray (Ericaceae) and *Hemitomes congestum* Gray (Ericaceae), but found no evidence of attack by flies. These are the only local parasitic plants with succulent stems like that of *Boschniakia,* though floral and stem morphology are quite different from *Boschniakia.*

Effects of *P. hyperparasitica* on its Host

Some insects, such as yucca moths and fig wasps, whose larvae feed on developing seeds, guarantee seed set by pollinating the host plant. The hairy abdomen of *P. hyperparasitica* may transfer pollen, but this transfer is not necessary for seed set, as the pollen of each flower is shed directly onto the stigma. Seed production and seed viability of flowers on plants in exclusion cages is equal to that of undamaged flowers on plants left in the open. The principle cross-pollinators appear to be bumble bees (*Bombus* spp.). If a substantial number of fly eggs fail to develop, or if the flies often make abortive oviposition attempts, the flies might be significant cross-pollinators, but this seems highly unlikely.

The larva has a great effect on seed production. Seed counts from 10 randomly collected plants taken in 1978 and again in 1979 indicated that about 90% of the seed crop was destroyed by flies both years. Undamaged capsules remaining on the plant usually develop normally, in spite of the damage to the stem. *B. hookeri*

Figure 9. Larval damage to stem of inflorescence.

is not usually an abundant plant, and the fly may well be partly responsible for its scarcity, though there is no way to test this idea.

Although the fly has a great effect on the inflorescence, it does not attack the underground tuber-like body of the plant. The fly does not exhaust the plant's resources, as no nutrient-storing portions are attacked, and may actually reduce the nutritional drain by the inflorescence if ovaries are consumed before their allocation of nutrients is complete. In this sense we consider the fly parasitic, as it never kills its host plant.

Conclusion

P. hyperparasitica is previously unknown species that appears to be morphologically and ecologically divergent from any known species or species groups of *Pegomya.* It attacks the reproductive parts of a species of plant which is itself morphologically and ecologically isolated. Although these flies can be easily found once the host is known, both fly and host are relatively uncommon organisms. This furnishes another example of a species that would not be known to entomologists were it not for the observations of botanists.

Acknowledgments

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